

# IMAGE READING APPARATUS AND IMAGE READING METHOD

## BACKGROUND OF THE INVENTION

### Field of the Invention:

The present invention relates to an image reading apparatus which reads an image which is recorded on a transmission original which is such as a photographic film or the like by light which has been transmitted through the transmission original, and an image reading method thereof.

### Description of the Related Art:

In recent years, a technology has become more common in which an image which is recorded on an original such as a photographic film or the like is photoelectrically read by using a photoelectric conversion element such as a CCD or the like and is stored as digital image data, and then image processings such as enlargement and reduction of the image, various corrections, and the like is carried out on the digital image data, and an image is formed on a recording material such as a photographic printing paper or the like by a light beam which is modulated on the basis of the data subjected to image processing.

Generally, in an image reading apparatus, infrared light, which is emitted from a lamp which serves as a light source, is cut off by using an infrared light cutting filter so as to prevent a photographic film from being damaged by the infrared light emitted from the light source.

On the other hand, if the photographic film which is the transmission original is scratched or if dust adheres to the photographic film, when image reading is carried out by the CCD or the like, the scratches and dust significantly affect image data. Then, when an image is formed on the recording material on the basis of the image data, the scratches and dust appear and affect the finish of the image which is formed on the recording material.

In an image reading apparatus, in order to avoid the influence of such scratches or dust on the original, diffused light is irradiated onto the original when an image is read.

In recent years, the demand for high image quality of images formed by a light beam or the like has been growing, and image reading of high precision is becoming necessary in image reading apparatuses. Thus, in an image reading apparatus, pre-scanning, in which an image recorded on an original is read at low resolution, is carried out and image reading conditions are set. Then, fine-scanning, in which an image is read at high resolution on the basis of the image reading conditions set by the pre-scan, is carried out. As a result, image data having high precision can be obtained.

When image reading is carried out with high precision, it is difficult to form image data which is not affected by scratches on the photographic film or dust adhering to the photographic film simply by irradiating diffused light onto an original.

On the other hand, infrared light, which is invisible light, is transmitted without being affected by a visible image recorded on a

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transmission original from visible light which has been transmitted through the transmission original, and corrects the visible image by invisible light which has been transmitted through the transmission original. The image reading apparatus includes a light source which emits visible light and invisible light to the transmission original, a first photoelectric conversion device which receives visible light which is emitted from the light source and is transmitted through the transmission original, a second photoelectric conversion device which receives invisible light which is emitted from the light source and is transmitted through the transmission original, and a reading controlling device in which the reading of an invisible light image, in which invisible light is received by the second photoelectric conversion device, is carried out so as to be synchronized with the reading of a visible light image, in which visible light is received by the first photoelectric conversion device.

In accordance with the first aspect of the present invention, together with visible light, invisible light is irradiated from the light source onto the transmission original. Visible light is transmitted in accordance with an image formed on the transmission original and invisible light is transmitted in accordance with smudges and scratches on the transmission original.

Visible light which has been transmitted through the transmission original is received by the first photoelectric conversion device and is read as image data. Invisible light is read by the second

photoelectric conversion device and is used for correcting the image data based on visible light.

The reading controlling device controls reading such that the receiving of invisible light by the second photoelectric conversion device is synchronized with the receiving of visible light by the first photoelectric conversion device. Accordingly, visible light and invisible light which have been transmitted through the transmission original can be received in parallel. Further, it is possible to read image data based on visible light and image data based on invisible light without separately carrying out scanning for reading visible light and scanning for reading invisible light.

When the visible light reading and the invisible light reading are effected by separate scannings, there is a drawback in that dust adhering to the transmission original may move, thereby generating discrepancies between the positions of the dust in the image read by visible light and the positions of the dust in the image read by invisible

light. However, in the present invention, by synchronizing the invisible light reading with the visible light reading, discrepancies in the positions of dust adhering to the transmission original are not generated. Therefore, the visible light image can be appropriately corrected on the basis of the invisible light image.

In accordance with a second aspect of the present invention, the reading controlling device is designed such that invisible light is received by the second photoelectric conversion device to read an invisible light image at the same time visible light is received by the first photoelectric conversion device to read a visible light image.

In accordance with the second aspect of the present invention, the receiving of invisible light is effected at the same time that the receiving of visible light is effected.

For example, when the receiving of visible light and the receiving of invisible light are carried out in parallel, the receiving of visible light and the receiving of invisible light may be alternatively carried out. When the receiving of visible light and the receiving of invisible light are alternatively carried out, in order to obtain predetermined resolution, it is necessary to extend reading time by reducing a conveying speed. However, by receiving visible light and receiving invisible light at the same time, reading time can be further shortened as compared with a case in which the receiving of visible light and the receiving of invisible light are alternatively carried out.

The first photoelectric conversion device of the present invention may read color images or may read monochrome images.

When the first photoelectric conversion device reads color images, for example, a CCD, which is separately provided as a light receiving element which receives R, G and B light, may be used, or a CCD, with which the light receiving element which receives respective color components of light is integrated, may be used.

As the second photoelectric conversion device, a light receiving element which receives infrared light as invisible light may be used or a light receiving element which receives ultraviolet light may be used.

Further, in the present invention, the first photoelectric conversion device may be integrated with the second photoelectric conversion device, or the first photoelectric conversion device and the second photoelectric conversion device may be separately disposed.

The present invention may include a deflecting device which selects and guides visible light which has been transmitted through the transmission original to the first photoelectric conversion device and which guides invisible light which has transmitted through the transmission original to the second photoelectric conversion device.

Accordingly, in the present invention, the receiving of visible light which has been transmitted through the transmission original and the receiving of invisible light which has been transmitted through the transmission original can be simultaneously carried out.

In accordance with a third aspect of the present invention, a light reducing device is included, which limits an intensity of invisible light emitted from a light source to a predetermined range.







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Therefore, when an invisible light image is read, blurring of the image can be prevented by the axial chromatic aberration. Accordingly, small dust particles or slight scratches on the transmission original can be detected, and when an image is read with high precision, it is possible to precisely correct a visible light image on the basis of the invisible light image.

In accordance with another aspect of the present invention, there is provided an image reading method which reads a visible image which is formed on a transmission original from visible light which has been transmitted through a transmission original and corrects the visible light by invisible light which has been transmitted through the transmission original. The image reading method includes a step of emitting visible light and invisible light to the transmission original, a

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Fig. 5 is a functional block diagram illustrating a schematic structure of the CCD scanner used in the first embodiment.

Fig. 6 is a timing chart of an example of timings for receiving visible light and invisible light, in accordance with the first embodiment.

Fig. 11 is a functional block diagram illustrating a schematic structure of the CCD scanner used in the second embodiment.

Fig. 12A is a timing chart illustrating an example of timings for receiving visible light and invisible light, and for lighting a light source, in accordance with the second embodiment.

Fig. 12B is a timing chart illustrating an example of timings for receiving visible light and invisible light, and for lighting the light source, which is applicable to the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

### *First Embodiment*

Embodiments of the present invention will be described in detail hereinafter with reference to the drawings. Figs. 1 and 2 show a schematic structure of a digital laboratory system 10 relating to the present embodiments.

The digital laboratory system 10 is structured to include an image processing section 16, a laser printer section 18, a processor section 20, and a CCD scanner 14 which serves as an image reading apparatus. As illustrated in Fig. 2, the CCD scanner 14 and the image processing section 16 are integrated to form an input device 26, and as illustrated in Fig. 1, the laser printer section 18 and the processor section 20 are integrated to form an output device 28.

The CCD scanner 14 reads a frame image recorded on a photographic film which is a transmission original such as a negative film, a reversal film, or the like. For example, the CCD scanner 14 may

read the frame image of a 135 size photographic film, a 110 size photographic film, a photographic film on which a transparent magnetic layer is formed (a 240 size photographic film which is known as an APS film), and 120 size and 220 size (brownie size) photographic films.

The CCD scanner 14 reads the frame image of the above-described photographic film for reading by a linear CCD 30 and the frame image is A/D converted by an A/D converter 32 (see Fig. 5), and then is outputted to the image processing section 16 as image data (scanned image data) of one read image (one frame). Hereinafter, a description will be given of an example in which a 135 size photographic film 22 (see Fig. 1) is used in the digital laboratory system 10 (see Figs. 1 and 3).

Scanned image data outputted from the CCD scanner 14 is inputted to the image processing section 16. As shown in Fig. 1, image data obtained by photographing using a digital camera 34 or the like can be inputted to the image processing section 16. Further, image data obtained by reading, in addition to the transmission original, a reflection original by a scanner 36 (flat-bed type), image data generated by a computer or the like, recorded on a recording medium, and inputted via a floppy disc drive 38, an MO drive or a CD drive 40 or the like, and image data (image file data) inputted by communication via a modem 42 or the like can be read in the image processing section 16.

The image processing section 16 stores inputted image data in an image memory 44, carries out image processings such as various types of correction in a color gradation processing section 46, a hyper processing section 48, a hyper sharpness processing section 50 and the like, and outputs the processed data to the laser printer section 18 as image data for recording. Further, the image processing section 16 can record the image data subjected to image processing, as image file data, in a storage medium (for example, floppy drive, MO, CD or the like) and output the image data to the outside, or the image processing section 16 can also output the image data to the outside via a communication line.

The input device 26 includes a keyboard 16K and a monitor 16M. A user can fetch images or carry out various image processings by operating keys of the keyboard 16K while looking at a display of the monitor 16K.

The laser printer section 18 temporarily stores the image data for recording inputted from the image processing section 16 in an image memory 56. The laser printer section 18 has R, G and B laser light sources 52, and an optical system including a polygon mirror 58, an f $\theta$  lens 60 and the like. Further, the laser printer section 18 controls a laser driver 54 such that laser light, which is modulated in accordance with the image data for recording stored in the image memory 56, is irradiated onto a photographic printing paper 62 to scan and expose the photographic printing paper 62. As a result, an

image in accordance with the image data for recording stored in the image memory 56 is recorded on the photographic printing paper 62.

The processor section 20 carries out various processings (development processings) such as color forming development, bleach-fixing, washing, and drying on the photographic printing paper 62 on which an image has been recorded by scan-exposure in the laser printer section 18. As a result, an image is formed on the photographic printing paper 62.

As illustrated in Fig. 3, the CCD scanner 14 is provided with a linear CCD 30. The linear CCD 30 is provided with CCD arrays 70R, 70G, and 70B (see Fig. 5) in which light receiving elements, which detect R, G and B colors, are adjacently disposed in a straight line in a direction perpendicular to a conveying direction of the photographic film 22. The CCD scanner 14 uses the CCD arrays 70R, 70G, and 70B to carry out image reading (scanning) on a line-by-line basis in the direction perpendicular to the conveying direction of the photographic film 22 which is conveyed at a constant speed.



invisible light as well as visible light including respective color components of R, G, and B. Thus, visible light and invisible light emitted from the light source 64 are irradiated onto the photographic film 22 which is loaded into the film carrier 78. In Fig. 3, the film carrier 78 is not illustrated.

A lens unit 72 and the linear CCD 30 are disposed at the side of a conveying path of the photographic film 22 opposite the side at which the light source 64 is disposed. Light, which has been transmitted through the photographic film 22, is imaged on the linear CCD 30 by the lens unit 72. In the CCD scanner 14, light, which has been transmitted through the photographic film 22, is accumulated on light receiving elements of respective CCD arrays 70R, 70G, and 70B of the linear CCD 30 and an electric signal, which corresponds to an amount of light accumulated by the respective light receiving elements, is outputted at a predetermined timing. This electric signal is A/D converted within the CCD scanner 14 and outputted as image data of respective color components.

Accordingly, R, G and B color separation images which are recorded on the photographic film 22 are read. The linear CCD may have a conventionally known structure, and detailed description thereof is omitted in the present embodiments.

A dichroic mirror 74 is disposed between the lens unit 72 and the linear CCD 30. As illustrated in Fig. 4, this dichroic mirror 74 is designed such that reflectances of respective color components of R, G and B (Rch, Gch, and Bch) of light, which is visible light, are low, but

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In this way, visible light, which has been transmitted through the lens unit 72 is transmitted through the dichroic mirror 74 and is imaged on the linear CCD 30, while infrared light, which has been transmitted through the photographic film 22 and the lens unit 72, is reflected by the dichroic mirror 74. The dichroic mirror 74 is, for example, tilted about 45° with respect to an optical axis of the lens unit 72 such that infrared light is reflected in a direction perpendicular to the optical axis. Here, in Fig. 4, areas of Rch, Gch, and Bch are shown by a double-dashed chain line. The reflectance of the dichroic mirror 74 is low in these areas.

As shown in Figs. 1 and 3, a linear CCD 68 for detecting infrared light is disposed in a direction in which the dichroic mirror 74 reflects the infrared light. The linear CCD 68 includes, as the linear CCD 30 does, a CCD array 70IR (see Fig. 5) in which light receiving elements are arranged in a straight line in a direction perpendicular to the conveying direction of the photographic film 22. Infrared light which is reflected by the dichroic mirror 74 is imaged on the linear CCD 68.

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the lens unit 72 is corrected, that is to say, the lens unit 72 is corrected (is made achromatic) such that R, G and B lights which have been transmitted through the same position on the photographic film 22 are imaged on CCD arrays 70R, 70G and 70B of the linear CCD 30, respectively.

On the other hand, the axial chromatic aberration of the lens unit 72 with respect to infrared light (IRch) remains uncorrected, and the focal position of infrared light deviates from the focal positions of R, G and B colors.

In the CCD scanner 14, an IR light reducing filter 76 which slightly transmits infrared light is disposed between the light source 64 and the conveying path of the photographic film 22. In order to prevent the photographic film 22 from being damaged by infrared light, an image reading apparatus or the like is generally provided with an IR cutting filter to cut substantially 100 % of infrared light unnecessary for image reading. In contrast, in the CCD scanner 14, the IR light reducing filter 76 is disposed such that a portion of infrared light emitted from the light source 64 is transmitted toward the photographic film 22.

The transmittance of the IR light reducing filter 76 with respect to infrared light is about 10 % to 50 %. The IR light reducing filter 76 is designed such that the intensity of infrared light which is transmitted through the IR light reducing filter 76 and is irradiated onto the photographic film 22 is set in a range in which the photographic film 22 is not damaged. Further, in the IR light reducing filter 76, when light receiving elements of the linear CCD 68 receive infrared light which has been transmitted through the photographic film 22 at the same timing of the linear CCD 30, infrared light is reduced such that the light receiving elements are not saturated, for example, the amount of light received by the light receiving elements is about 50 % of the saturation amount thereof.

As shown in Fig. 1, the CCD scanner 14 includes a read data correction section 80. As shown in Fig. 5, the read data correction section 80 includes amplifiers 82 and an A/C converter 32. R, G and B electric signals which are outputted from the linear CCD 30 are inputted to the A/D converter 32 via amplifiers 82. Further, the read data correction section 80 includes an amplifier 82 and an A/D converter 33 so as to correspond to the linear CCD 68. Output of the linear CCD 68 which receives infrared light is inputted to the A/D converter 33 via the corresponding amplifier 82.





frame basis. In this way, R, G and B pre-scanned image data for each frame are read.

In the CCD scanner 14, on the basis of image data read by pre-scanning, reading conditions at the time at which fine-scanning is carried out are set on a frame-by-frame basis. The image data which is read by pre-scanning is displayed on, for example, the monitor 16M.

In the CCD scanner 14, when a frame of the photographic film 22 reaches a predetermined position, the linear CCDs 30 and 68 are operated on the basis of the synchronized signal T outputted from the synchronized signal generating circuit 92 to successively read R, G and B color separation images and an infrared light image on a line-by-line basis. Outputs of the linear CCDs 30 and 68 are successively A/D converted by the A/D converters 32 and 33 so as to be stored in the frame memories 84 and 86.





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In this way, in the CCD scanner 14, infrared light which has been transmitted through the photographic film 22 can be detected together with respective color components of R, G, and B of light which have also been transmitted through the photographic film 22.

Accordingly, R, G and B image data read with high precision can be accurately corrected by infrared light image data.

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signal T is also outputted to the linear CCD 68 which detects infrared light.

As illustrated in Fig. 6, in the CCD scanner 14, when an image frame recorded on the photographic film 22 reaches a predetermined position, while the photographic film 22 is conveyed at a constant speed, the receiving of visible light by the linear CCD 30 and the receiving of invisible light by the linear CCD 68 begin simultaneously. At this time, the linear CCDs 30 and 68 receive visible light and invisible light respectively at predetermined intervals, and output electric signals corresponding to amounts of light received as image data of one line. In Fig. 6, when the linear CCDs 30 and 68 are turned on, light (light energy) is accumulated, and when the linear CCDs 30 and 68 are turned off, electric signals in accordance with the accumulated light energy (amount of light received) are outputted.

Scratches generated on the photographic film 22 and dust adhering thereto are detected, and image data is corrected on the basis of the detected results. Therefore, additional time for reading infrared light in order to obtain high quality image data is not necessary, and the reading of an infrared light image can be carried out while the reading of R, G and B images is carried out.



timing for turning off the linear CCD 30 (a timing that the receiving of light for one line is finished) may be adjusted to a timing for turning off the linear CCD 68. Further, as illustrated in Fig. 7C, the linear CCD 30 may be synchronized with the linear CCD 68 such that the linear CCD 68 turns off when the linear CCD 30 starts the receiving of light for the next one line. As illustrated in Fig. 7D, the linear CCD 68 may be turned on or off while the linear CCD 30 turns on.

In the above-described first embodiment, a description has been given of a structure in which R, G and B image data and infrared light image data are read by the linear CCD 30 in which R, G and B light receiving elements are integrally arranged, and by the linear CCD 68 in which light receiving elements for infrared light are used, but the present invention is not limited to this structure.

For example, linear CCDs may be used for respective colors of R, G and B, and IR. Namely, as illustrated in Fig. 8, a linear CCD 100 in which a CCD array 70R is provided, a linear CCD 102 in which a CCD array 70G is provided, a linear CCD 104 in which a CCD array 70B is provided, and a linear CCD 68 in which a CCD array 70IR is provided, may be used.

In this case, in addition to a dichroic mirror 74 for infrared light, dichroic mirrors 74R, 74G, and 74B, whose reflectances with respect to respective colors of R, G, and B are high, are disposed on the optical axis, and the linear CCDs 100, 102, and 104 are disposed in reflecting directions of dichroic mirrors 74R, 74G, and 74B.

As shown in Fig. 9, instead of a dichroic mirror, a dichroic prism 106 may be used. The dichroic prism 106 is designed such that its refraction direction is changed for R, G and B, and IR. The linear CCDs 100, 102, 104, and 68 are disposed in refraction directions of R, G, B, and IR, respectively.

In the first embodiment, the dichroic mirror 74 is used to separate R, G and B of visible light from infrared light which is invisible light, but the present invention is not limited to this case. For example, a so-called dichroic prism, whose refractive index with respect to visible light is different from that with respect to invisible light, may also be used. In this case, the linear CCD 30 is disposed in a refraction direction of visible light from the dichroic prism and the linear CCD 68 is disposed in a refraction direction of the infrared light which is invisible light.

### Second Embodiment

Fig. 10 shows a schematic structure of a CCD scanner 110 used in the second embodiment. In the CCD scanner 110, instead of the IR light reducing filter 76 in the CCD scanner 14 used in the first embodiment, a conventionally known IR cutting filter 112 is provided.

Infrared light, which is invisible light and emitted together with visible light from a light source, is blocked by the IR cutting filter 112 such that only visible light is illuminated onto the photographic film 22.

On the other hand, in the CCD scanner 110, a dichroic mirror 74A which reflects the infrared light is disposed on the optical axis between the IR cutting filter 112 and a conveying path of the photographic film 22. Further, the CCD scanner 110 is provided with an IR-LED 114 as a light source which faces an infrared light reflecting surface of the dichroic mirror 74A and emits infrared light.

Accordingly, infrared light emitted from the IR-LED 114 is reflected by the dichroic mirror 74A to be irradiated onto the photographic film 22 together with visible light emitted from the light source 64.

The CCD scanner 110 is provided with a linear CCD 116 which includes CCD arrays 70R, 70G, 70B, and 70IR in which light receiving elements of R, G and B, and IR are respectively arranged in straight lines. Visible light and infrared light which have been transmitted through the photographic film 22 and the lens unit 72 are imaged on the linear CCD 116. The CCD array 70IR is disposed at a position in

which, in accordance with the axial chromatic aberration of the lens unit 72, the axial chromatic aberration is eliminated.

As illustrated in Figs. 10 and 11, the CCD scanner 110 is provided with a driving circuit 118 which drives and turns on the IR-LED 114. As shown in Fig. 11, the synchronized signal T, which is generated in a synchronized signal generating section 92, is inputted to the driving circuit 118. The driving circuit 118 drives the IR-LED 114 on the basis of the synchronized signal T.

The driving circuit 118 drives and turns on the IR-LED 114 such that the intensity of infrared light emitted from the IR-LED 114 does not damage the photographic film 22 and the CCD array 70IR is not saturated.

In the CCD scanner 110 which is structured as described above, when pre-scanning is finished, fine-scanning starts on the basis of image reading conditions set by the pre-scan.

In the CCD scanner 110, when the fine-scan starts, while the photographic film 22 is conveyed at a predetermined speed  $v$ , the linear CCD 116 is operated on the basis of the synchronized signal T generated at the synchronized signal generating section 92 such that R, G and B color component data are fetched on a line-by-line basis. At this time, on the basis of the synchronized signal T generated in the synchronized signal generating section 92, the driving circuit 118 drives the IR-LED 114 for a predetermined period of time. In this way, the IR-LED 114 emits infrared light and the infrared light is





be synchronized with the receiving of visible light by the CCD arrays 70R, 70G, and 70B, visible light and invisible light can be alternatively received by the CCD arrays 70R, 70G and 70B, and the CCD array 70IR.

That is to say, as shown in Fig. 12B, when the CCD arrays 70R, 70G, and 70B are turned off, the CCD array 70IR is turned on. When the CCD array 70IR is turned off, the CCD arrays 70R, 70G, and 70B are turned on.

In order to obtain predetermined resolution, it is necessary to convey the photographic film 22 at a speed of  $v/2$  at this time. However, time can be reduced in comparison with a case in which the scanning of visible light and the scanning of invisible light are separately carried out.

Because the IR-LED 114 turns off when the CCD array 70IR turns on, the CCD arrays 70R, 70G, and 70B do not receive infrared light emitted by the IR-LED 114. Among the CCD arrays 70R, 70G, and 70B which receive visible light, there are some CCD arrays whose light receiving amount is effected by the infrared light. When visible light is received by the CCD arrays 70R, 70G, and 70B, the IR-LED 114 is turned off, and therefore, image data, in which only visible light is appropriately received, can be obtained.

When scanning using visible light and scanning using invisible light are carried out separately, dust adhering to the photographic film 22 may move because there is a large time difference between scanning using visible light and scanning using invisible light

and conveyance of the photographic film 22 may effect scanning. However, by carrying out scanning using visible light and scanning using invisible light in parallel, dust adhering to the photographic film 22 can be prevented from moving between the time when visible light is received and the time when invisible light is received. Therefore, appropriate image data using invisible light can be obtained.

In the above-described embodiments, although a linear CCD is used as first and second photoelectric conversion devices, another structure such as an area CCD or the like may be used. When the area CCD is used, the photographic film 22 is conveyed on a frame-by-frame basis and an image frame is stopped at a position which faces the area CCD and then image reading is carried out.

In the present embodiments, a description has been given of the CCD scanners 14 and 110 provided in the digital laboratory system 10 which are applied to the present invention, but the CCD scanners 14 and 110 may be used as a single unit. The present invention can be applied to various image reading apparatuses in which an image can be read from, in addition to the photographic film, various transmission originals.

Although infrared light is used as invisible light in the present embodiments, in addition to the infrared light, ultraviolet ray may be used. In this case, a light source which emits the ultraviolet ray is provided together with a light source which emits visible light to detect image data of the ultraviolet ray which has been transmitted through a transmission original.

As described above, according to the present invention, the reading of image data based on invisible light such as infrared light can be effected at the same time that the reading of R, G and B image data is effected. Therefore, extended image reading time due to the detection of scratches or dust adhering to the transmission original being carried out by using invisible light can be prevented. Thus, accurate image data can be obtained and the present invention has excellent effects.

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